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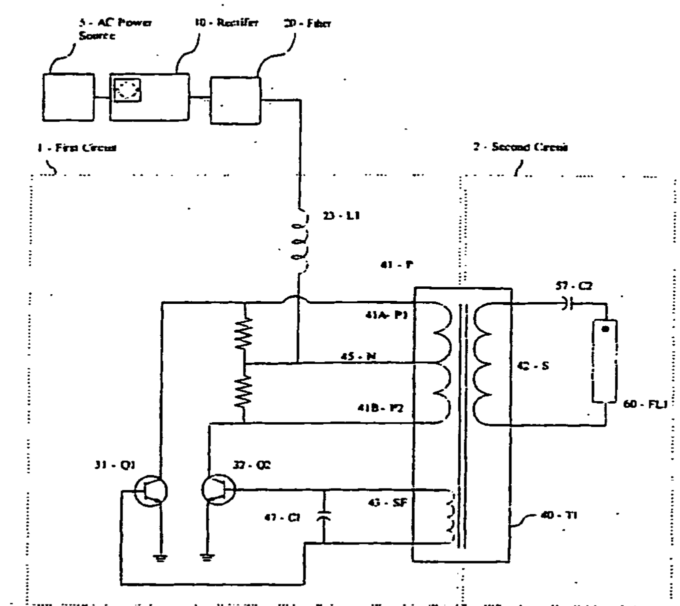
(54) Title: HIGH FREQUENCY ELECTRONIC BALLAST



(57) Abstract: A high frequency sinusoidal wave is generated and applied directly to a gas discharge lamp in a power efficient electronic ballast. Uniting a high frequency current fed oscillator with a transformer, where direct current may be applied to the center tap of the transformer primary winding to enable the impression of a sinusoidal alternating current at the secondary winding. This sinusoidal alternating current is applied directly to a gas discharge lamp. Feedback from the transformer controls the switching of the oscillator at resonant frequency.

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Declarations under Rule 4.17:

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*

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INTERNATIONAL PATENT APPLICATION

HIGH FREQUENCY ELECTRONIC BALLAST

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under USC 119(e) of provisional patent application Serial No. 60/316,240 filed on August 31, 2001, entitled "High Efficiency Method for Driving Gas Discharge Lamps," which is hereby incorporated by reference in its entirety.

BACKGROUND

FIELD OF THE INVENTION

The present invention relates generally to electronic ballasts for gas discharge lamps. More specifically, this invention relates to the production of a high efficiency electronic ballast by unifying power and lamp control at a high, resonant frequency of alternating current applied directly to fluorescent lamps.

DESCRIPTION OF BACKGROUND ART

Fluorescent light operates by creating a discharge or arc across an ionized gas within a glass tube. In traditional fluorescent lighting, the gas tube is filled with mercury vapor which, when ionized, can collide with electrons of a current flow across the electrodes of a lamp, and emit photons. These photons strike fluorescent material on the inner wall of the glass tube and produce visible light.

Fluorescent lamps require a ballast to operate. The ballast conditions the electric power to produce the input characteristics needed for the lamp. When arcing, the lamp exhibits a negative resistance characteristic, and therefore needs some control to avoid a cascading discharge. Both manufacturers and the American National Standards Institute specify lamp characteristics, which include current, voltage, and starting conditions. Historically, 50-60 Hz ballasts relied on a heavy core of magnetic material; today, most modern ballasts are electronic.

Electronic ballasts can include a starting circuit and may or may not require heating of the lamp electrodes for starting or igniting the lamp. Prior to ignition, a lamp acts as an open circuit; when an arc is created the lamp starts, the entire ballast starting voltage is applied to the lamp. After ignition, the current through the lamp increases until the lamp voltage reaches equilibrium based on the ballast circuit. Ballasts can also have additional circuitry designed to filter electromagnetic interference (EMI), correct power factor errors for alternating current power sources, filter noise, etc.

Electronic ballasts typically use a rectifier and an oscillating circuit to create a pulsed flow of electricity to the lamp. Common electronic lighting ballasts convert 60 Hz line or input current into a direct current, and then back to a square wave alternating current to operate lamps near frequencies of 20-40 kHz. Some lighting ballasts further convert the square wave to more of a sine wave, typically through an LC resonant lamp network to smooth out the pulses to create sinusoidal waveforms for the lamp. See, for example, U.S. Pat. No. 3,681,654 to Quinn, or U.S. Pat. No. 5,615, 093 to Nalbant.

The square wave approach is common for a number of reasons. Many discrete or saturated switches are better suited to the production of a square wave than a sinusoidal wave. In lower frequency applications, a square wave provides more consistent lighting; a normal sinusoid at low frequency risks de-ionization of the gas as the voltage cycles below the discharge level. A square wave provides a number of other features, such as constant instantaneous lamp power, and favorable crest factors. With a square wave, current density in the lamp is generally stable, promoting long lamp life; similarly, there is little temperature fluctuation, which avoids flicker and discharge, damaging the lamp.

It is known that higher frequencies can produce more efficient lighting. In general, if de-ionization is minimized or avoided, then less energy is needed because there is no re-ionization of the gas; that is, a higher frequency avoids the cycle of decay and recovery of ionization within the lamp. Further, the anode fall voltage can be lower when the frequency is higher than the oscillation frequency of the plasma.

However, higher frequency ballasts suffer some problems. First, electronic ballasts can create harmonic disturbance, due in part to the use of pulses or square wave signals. Harmonics are signals in which the frequency is a whole number multiple of the system's fundamental frequency; the third harmonic is most damaging. The total harmonic distortion (or "THD") is one measure of ballast performance. Harmonics create unexpected or nonlinear loading of circuit elements; the harmonic signals cause voltage drops at points of impedance, at the frequency of the harmonic current. At high frequency, the circuitry required to convert a square wave into a sinusoidal wave may limit the available frequency of operation; high frequency voltage drops can change the voltage values of the fundamental wave. A ballast with a high THD may also create electromagnetic interference with nearby electrical equipment, necessitating additional circuitry to filter harmonics; however, such circuits can introduce additional problems such as high inrush current. Second, as discussed in U.S. Pat. No. 5,173,643 to Takehara, it is generally believed that operating frequencies above 50KHz may introduce stray capacitance into lamp circuitry. Finally, the semiconductor switches of many oscillating circuits in electronic ballasts have faced inefficiency or losses, including thermal dissipation, at high frequency driving. Thus, ballast technology has heretofore been limited, thereby also limiting the opportunity for improved energy efficiency.

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SUMMARY OF THE INVENTION

The present invention is an electronic ballast that applies a high frequency sinusoidal wave directly to a gas discharge lamp. The basic idea consists of uniting a high frequency oscillator with elements traditionally located within a lamp network; the output of the oscillator is applied to a lamp, preferably using a center tapped primary winding of a transformer, with the secondary winding of such transformer is in series with the lamp electrode feeder. The lamp is maintained at its striking voltage, and energy consumption low. Feedback and tuning ensures that the lamp is operated at a very high, resonant fundamental frequency. In this way, power control and lamp control are integrated to achieve high levels of efficiency.

DESCRIPTION OF DRAWINGS

Fig. 1 shows a block diagram of typical electronic ballast.

Fig. 2 shows a block diagram of an embodiment of the present invention.

Fig. 3 shows a wiring diagram for an embodiment of the present invention adapted for receiving a direct current input.

Fig. 4 shows a wiring diagram for an embodiment of the present invention adapted for receiving an alternating current input.

REFERENCE NUMERALS

1 First Circuit
2 Second Circuit
5 Alternating Current Power Source
6 Direct Current Power Source
10 Rectifier

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20	Filter
23	L1 Inductor
30	Oscillator
31	Q1 Transistor
32	Q2 Transistor
40	T1 Transformer
41	P Primary Winding
41A	P1 First Portion of Primary Winding
41B	P2 Second Portion of Primary Winding
42	S Secondary Winding
43	SF Feedback Winding
45	N Center Tap of Transformer 40
47	C1 Resonating Capacitor
57	C2 Ballast Capacitor
60	FL1 Gas Discharge Lamp

DETAILED DESCRIPTION OF THE INVENTION

As noted above, the present invention is an electronic ballast that applies a high frequency sinusoidal wave directly to a gas discharge lamp. Figure 1 shows a basic block diagram of the typical approach to electronic ballasts; a rectifier converts an alternating current source into direct current, which is filtered and then passes to an oscillator to generate a square wave at a frequency from 20 to 40 KHz. A lamp network is required to condition the square wave for the lamp; this conditioning includes treatment of the wave as described above, such as filtering harmonic distortion and noise, and possibly modifying the square wave form to create more of a sinusoidal shape - if desired for the application. Figure 2 is a basic block diagram of the configuration of an embodiment of the present invention, adapted to receive an alternating current input. This design applies a fundamental, higher frequency, sinusoidal alternating current directly to the lamp using a unified approach. As shown, here also a rectifier converts the alternating current input into a direct current, which is then filtered to remove any alternating current ripple; in general, an L-C or Pi filter, or their equivalents would serve this function. This invention is not limited to alternating current sources of input power; the rectifier and filter may be omitted for applications involving a direct current input. A current limiting inductance receives the filtered direct current and applies it to a center tapped transformer. An oscillator, in conjunction with the center tapped transformer, converts the filtered direct current into a high frequency alternating current across the primary of current transformer. Feedback from the transformer is tuned by resonant capacitance, so that the oscillator operates at the fundamental frequency of the circuit.

Figure 3 shows in greater detail a general embodiment of the present invention for an alternating current input. The alternating current input 5 is converted to a direct current by rectifier 10, which may be one of any number of designs known in the art and capable of producing a direct current from an alternating current. A clean direct current that is free from any line or alternating current ripple is desired for embodiments with alternating current input in order to maintain the purity of the oscillator resonant frequency. Any ripple frequency energy could modulate the gas discharge lamp, and reduce efficiency. Accordingly, filter 20 is located after rectifier 10. Filter 20 is not shown in detail, as these are also well known in the art. In addition, those skilled in the art will recognize that with a direct current power supply or input, rectifier 10 and filter 20 may be omitted, as shown in Figure 4, or replaced with a single diode or other such components appropriate for that direct current input. Inductor (L1) 23 receives the filtered direct current, and acts to limit current change. As discussed below, inductor (L1) 23 plays a role in setting the voltage ultimately applied to lamp 60. The output of inductor (L1) 23 is applied to center tap (N) 45 of primary winding (P) 41 of transformer (T1) 40; that is, center tap (N) 45 splits the primary winding (P) 41 of transformer (T1) 40 into of primary winding 41 into a first portion (P1) 41A and a second portion (P2) 41B, as shown in Figure 3.

In this embodiment, transistors (Q1) 31 and (Q2) 32 are joined collector to collector, with the junction occurring across primary winding (P) 41 of transformer (T1) 40. That is, each end of primary winding (P) 41 connects to a collector of one of transistors (Q1) 31 and (Q2) 32. Secondary winding (S) 42, coupled to primary winding (P) 41, is positioned in series with gas discharge lamp (FL1) 60. It is desirable to introduce some capacitance in series with lamp (FL1) 60 and secondary winding (S) 42 in order to offer some ballast and provide direct current blocking for lamp (FL1) 60. This capacitance is represented by capacitor (C2) 57, but could also include alternate configurations of circuit design available to create a capacitance in the absence of a discrete, separate component, as is known in the art. By way of example and not limitation, such configurations may include alternatives such as placing two conductors near each other without touching. Thus, capacitor (C2) 57 is in series with secondary winding (S) 42 and lamp (FL1) 60, thereby making up second circuit 2 for this embodiment. This design may include other circuitry as desired for the particular application; for example, the invention may include one or more heaters, which are generally omitted for use with cold cathode fluorescent lamps.

The no load voltage impressed on the secondary winding (S) 42 of transformer (T1) 40 is preferably approximately equal to the strike voltage of lamp (FL1) 60. The alternating current output voltage of oscillator 30 at transformer (T1) 40 is a linear function of the voltage at inductor (L1) 23. Those skilled in the art will readily see how components of a variety of values could achieve this objective.

A third or feedback winding (SF) 43 is provided by transformer (T1) 40; conservatively, feedback winding (SF) 43 may be coupled either to primary winding (P) 41 or secondary winding (S) 42. Those skilled in the art will recognize that such feedback may be provided in a variety of ways to achieve a similar effect, possibly even arranged by a separate transformer. The bases of transistors (Q1) 31 and (Q2) 32 are joined across feedback winding (SF) 43, with a resonating capacitor (C1) 47 in parallel with such third coil. Resonating capacitor (C1) 47 may alternatively be located in parallel with primary winding (P) 41, secondary winding (S) 42, or a combination thereof.

For ease of description, this embodiment is shown in a configuration that supports single-phase applications. Those skilled in the art will recognize the invention's ready adaptability to multi-phase operation, with minor changes in individual components that are well known. For example, transformer (T1) 40 is described above as comprising a primary winding (P) 41 with center tap (N) 45. For three-phase operation, transformer (T1) 40 could be implemented with three primary windings, such as a WYE transformer, with a center tap common to the three primary windings. Accordingly, it is intended that elements such as windings, transistors, or other circuit components be construed as including all known modifications to enable multi-phase operation. That is, with respect to the above example, primary winding (P) 41 should be construed as a primary winding or windings appropriate for the number of phases of the application.

Similarly, the above examples are shown with a single lamp (FL1) 60, which is intended to be construed as one or more gas discharge lamps, with such minor adaptations to second circuit 2 as are known in the art. Transistors (Q1) 31 and (Q2) 32 may be bipolar, FET, or other equivalents. In some embodiments, a power conversion stage may be included with a basic Royer circuit in order to regulate lamp power from line voltage changes. For the purposes of this specification and the appended claims, the terms "connected" or "joined" mean that there exists a conductive path, which may include elements that are not explicitly recited.

OPERATION OF THE BALLAST

The electronic ballast described above is designed to produce a more efficient conversion of input energy into light. By applying a sinusoidal alternating current to the lamp at high frequency, preferably between 100KHz to 250KHz, the ballast prevents de-ionization and improves efficiency. A unified approach to the generation and application of a sinusoidal wave eliminates the two step creation of a discrete square wave that must then treated by an L-C or other circuit to render it more sinusoidal. Such a two step approach is vulnerable to harmonic distortion, electromagnetic interference, and noise. The generation of a pure sine wave, which suits gas discharge lamps, and is cleaner. Although the present invention is operable with lamps of a variety of sizes, the use of physically smaller lamps, e.g., T1 through T3 (those of a diameter of 1/8 to 3/8 inches), demonstrated better lighting performance. The use of tri- or quad- phosphor lamps will further increase light output bandwidth within the visible frequency spectrum.

With reference to Figure 3, a current-fed oscillator may be employed to convert a direct current into a sinusoidal alternating current for driving a lamp. A direct current is applied to inductor (L1) 23. The oscillation is formed when transistors (Q1) 31 and (Q2) 32 alternatively switch, conducting against the impedance of inductor (L1) 23, into center tap (N) 45, and across the respective portions of primary winding (P) 41 to form a sinusoidal alternating current. The voltage of the alternating current is a linear function of the voltage at inductor (L1) 23, determining the wave amplitude. A base signal for transistors (Q1) 31 and (Q2) 32 is provided by feedback winding (SF) 43, which is timed by parallel capacitor (C1) 47. Selection of the values of the individual components of the unified electronic ballast should preferably produce a no load voltage for the alternating current equal to the strike voltage of lamp (FL1) 60. An induced sinusoidal alternating current is produced in secondary (S) 42 by its coupling with primary (P) 41. The current at lamp (FL1) 60 is ballasted by a small, high-voltage capacitor (C2) 57 positioned in series with lamp (FL1) 60. Capacitor (C2) 57 may also perform direct current blocking to resist lamp mercury migration.

In general, the operating frequency of an oscillator is determined by the resonant frequency of the tank circuit formed by the capacitive and inductive components, and the load that is coupled across the output, such as transformer (T1) 40. In this case the oscillation occurs at the loaded resonant frequency of the network formed by capacitor (C1) 47, the magnetizing inductance of primary winding (P) 41, and the reflected impedance of the output load at secondary winding (S) 42 (lamp, capacitor (C2) 57, and any stray capacitance). Capacitor (C1) 47 may be placed across, (i.e., in parallel with) any winding or combination of windings of transformer (T1) 40 to achieve the desired effect. Preferably this oscillator operates at a frequency between 100KHz and 250KHz.

The sinusoidal shape of the alternating current is dependent upon the quality factor or "Q value" of the loaded circuit. The loaded Q value is preferably greater than 3 to ensure stable operation; a value between 6 and 12 may be typical. Another aspect of the relatively high Q factor is that a large amount of energy circulates within the circuit relative to the amount of power delivered to the gas discharge lamp. In a less efficient design at high frequency, this characteristic could cause stray capacitance, losses, noise, and interference, particularly if the lamp requires greater energy. In the preferred embodiment, a relatively high current circulates on side of primary winding (P) 41 of transformer (T1) 40 at a relatively low voltage, and a lower current circulates on the side of secondary winding (S) 42 of transformer (T1) 40, at a relatively higher voltage. Inasmuch as it is an object of the present invention to reduce power consumption for lighting, the topologies described are well suited to operation at lower power levels. For example, the present invention has shown the ability to provide 100 Watts of effective lighting for 15 Watts of power in a hot cathode lamp and 7.5 Watts of power in a cold cathode lamp.

While the preferred embodiment of the invention, and its operation have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

What is claimed is:

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CLAIMS

1. A unified electronic ballast for a gas discharge lamp, comprising:

a first circuit adapted to produce a sinusoidal alternating current with a frequency at or in excess of about 70 KHz, and a voltage approximately equal to the strike voltage of said gas discharge lamp; and

a second circuit adapted to receive and apply said sinusoidal alternating current to said gas discharge lamp.

2. The unified electronic ballast in claim 1, wherein said first circuit first circuit is adapted to produce a sinusoidal alternating current approximately within the band of 100 KHz to 250 KHz.

3. The unified electronic ballast as described in claim 1, wherein the first circuit further comprises a rectifier adapted to convert alternating current into a direct current, a filter adapted to remove any alternating current ripple from said direct current, and an oscillator adapted to create said sinusoidal alternating current at the fundamental frequency of said first circuit.

4. The unified electronic ballast as described in claim 3, wherein said oscillator comprises a plurality of transistors.

5. The unified electronic ballast as described in claim 4, wherein said oscillator further comprises a current limiting inductor.

6. The unified electronic ballast as described in claim 5, which further comprises a center tapped transformer, configured such that:

the output of said inductor is applied to a center tap of a primary winding of said transformer;

at least two of the plurality of transistors have collectors that are joined at the ends of said primary winding of said transformer;

a secondary winding of said transformer, coupled to said primary winding, wherein said secondary winding is in series with said gas discharge lamp;

a feedback winding of said transformer, wherein said feedback winding is in series with and joins the bases of said at least two of said plurality of transistors;

at least one capacitor is positioned in parallel to at least one of the windings of said transformer; and

a capacitor is positioned in series with such secondary of said transformer.

7. The unified electronic ballast as described in claim 5, which further comprises a center tapped transformer, configured such that:

the output of said inductor is applied to a center tap of a primary winding of said transformer;

at least two of the plurality of transistors have collectors that are joined at the ends of said primary winding of said transformer;

a secondary winding of said transformer, coupled to said primary winding, wherein said secondary winding is in series with said gas discharge lamp;

a feedback winding of said transformer, wherein said feedback winding is in series with and joins the bases of said at least two of said plurality of transistors;

at least one capacitor is positioned in parallel to at least one of the windings of said transformer; and

a means for introducing a capacitance in series with such secondary of said transformer.

8. The unified electronic ballast as described in claim 1, wherein the first circuit is adapted to receive a direct current, and comprises an oscillator adapted to create said sinusoidal alternating current at the fundamental frequency of said first circuit.

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9. The unified electronic ballast as described in claim 8, wherein said oscillator comprises a plurality of transistors.

10. The unified electronic ballast as described in claim 9, wherein said oscillator further comprises a current limiting inductor.

11. The unified electronic ballast as described in claim 10, which further comprises a center tapped transformer, configured such that:

the output of said inductor is applied to a center tap of a primary winding of said transformer;

at least two of the plurality of transistors have collectors that are joined at the ends of said primary winding of said transformer;

a secondary winding of said transformer, coupled to said primary winding, wherein said secondary winding is in series with said gas discharge lamp;

a feedback winding of said transformer, wherein said feedback winding is in series with and joins the bases of said at least two of said plurality of transistors;

at least one capacitor is positioned in parallel to at least one of the windings of said transformer; and

a capacitor is positioned in series with such secondary of said transformer.

12. The unified electronic ballast as described in claim 10, which further comprises a center tapped transformer, configured such that:

the output of said inductor is applied to a center tap of a primary winding of said transformer;

at least two of the plurality of transistors have collectors that are joined at the ends of said primary winding of said transformer;

a secondary winding of said transformer, coupled to said primary winding, wherein said secondary winding is in series with said gas discharge lamp;

a feedback winding of said transformer, wherein said feedback winding is in series with and joins the bases of said at least two of said plurality of transistors;

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at least one capacitor is positioned in parallel to at least one of the windings of said transformer; and

a means for introducing a capacitance in series with such secondary of said transformer.

13. A method for driving a gas discharge lamp from a unified electronic ballast, which comprises:

producing a sinusoidal alternating current at a frequency at or above about 70 kHz, and a voltage approximately equal to the strike voltage of said gas discharge lamp; and

applying such alternating current to said gas discharge lamp.

14. A method for driving a gas discharge lamp from a unified electronic ballast, which comprises:

producing a sinusoidal alternating current at a frequency approximately within the band of 100 KHz to 250 KHz., and a voltage approximately equal to the strike voltage of said gas discharge lamp; and

applying such alternating current to said gas discharge lamp.

15. The method described in claim 13 wherein the step for producing a sinusoidal alternating current further comprises applying a direct current to an inductor, and then to an oscillator adapted to produce such sinusoidal alternating current at the fundamental frequency of said electrical ballast.

16. The method described in claim 15, wherein the step for producing a sinusoidal alternating current comprises applying the output of said oscillator across a primary winding of a center tapped transformer, wherein the secondary winding of said transformer is in series with said gas discharge lamp.

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17. The method described in claim 16, wherein the step for producing a sinusoidal alternating current further comprises controlling said oscillator at a fundamental frequency of said electronic ballast by feedback from said center tapped transformer with a resonant capacitance.

18. The method described in claim 13, wherein the step for producing a sinusoidal alternating current further comprises:

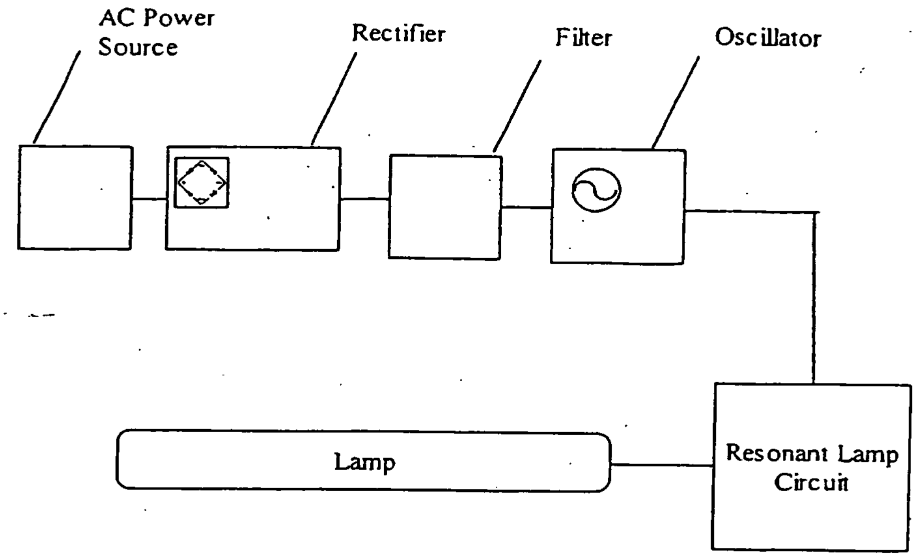
rectifying an alternating current to produce a direct current;
filtering such direct current to remove any alternating current ripple;
applying such filtered direct current to an inductor and then to an oscillator adapted to produce said sinusoidal alternating current at the fundamental frequency of said electronic ballast.

19. The method described in claim 18, wherein the step for producing a sinusoidal alternating current further comprises applying the output of said oscillator across a primary winding of a center tapped transformer, wherein the secondary winding of said transformer is in series with said gas discharge lamp.

20. The method described in claim 19, wherein the step for producing a sinusoidal alternating current further comprises controlling said oscillator at a fundamental frequency of said electronic ballast by feedback from said center tapped transformer with a resonant capacitance.

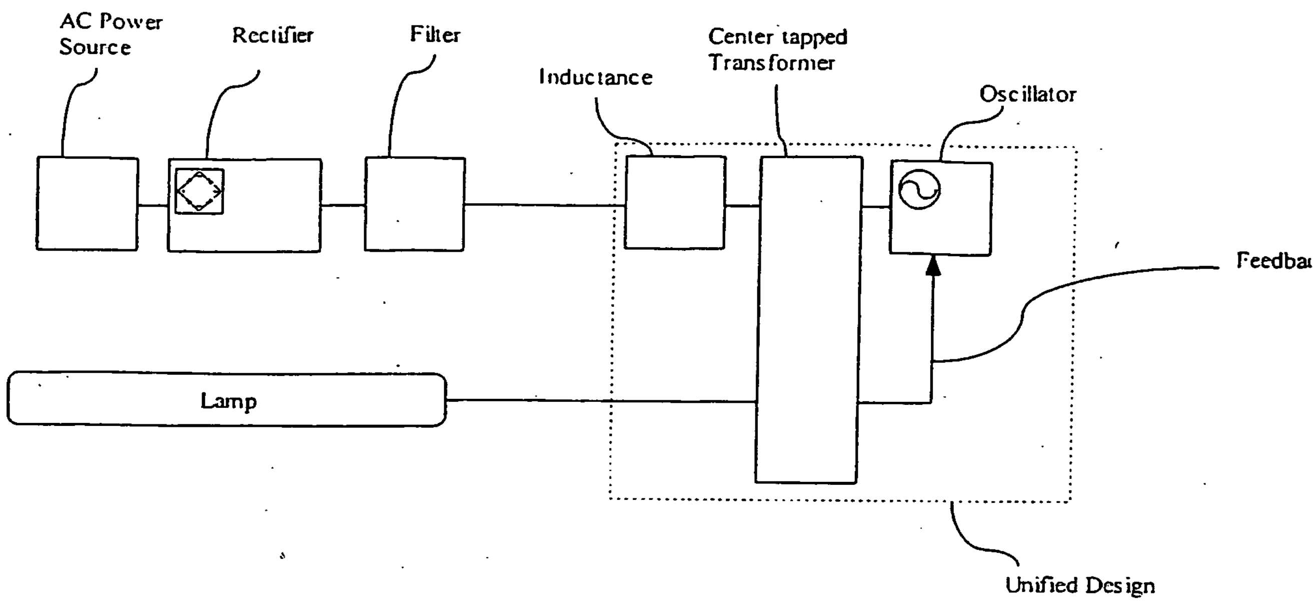
21. The unified electronic ballast for a gas discharge lamp described in claim 1, wherein all or a portion of said first and second circuits are located within the gas discharge lamp.

22. The unified electronic ballast for a gas discharge lamp described in claim 1, wherein all of said first and second circuits are located outside of the gas discharge lamp.



TYPICAL ELECTRONIC BALLAST (PRIOR ART)

FIG. 1



A UNIFIED DESIGN HIGH FREQUENCY ELECTRONIC BALLAST

FIG. 2

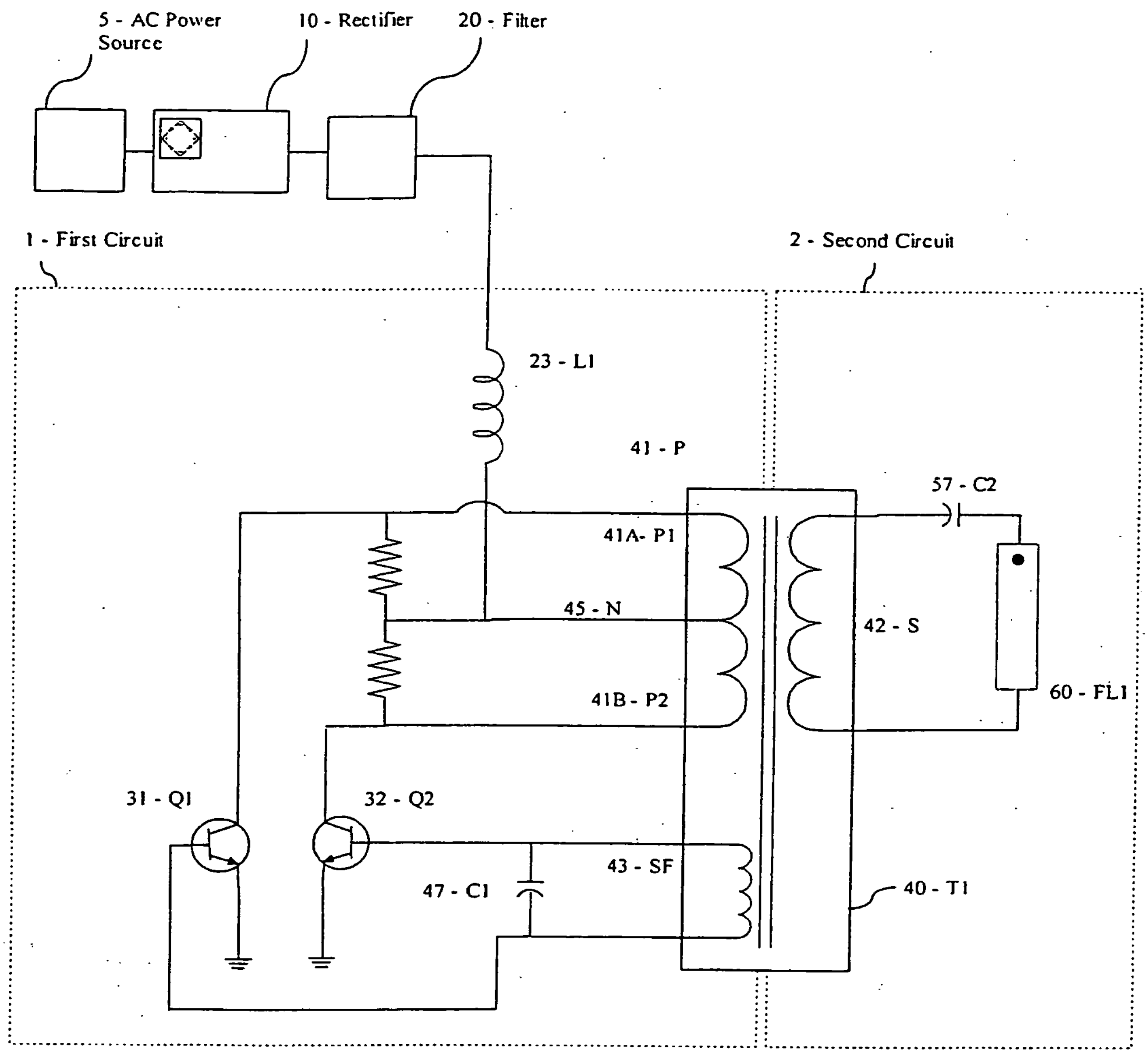

5 - AC Power Source
10 - Rectifier
20 - Filter
1 - First Circuit
2 - Second Circuit
23 - L1
41 - P
57 - C2
41A- P1
45 - N
42 - S
41B - P2
60 - FL1
31 - Q1
32 - Q2
43 - SF
47 - C1
40 - T1

FIG. 3

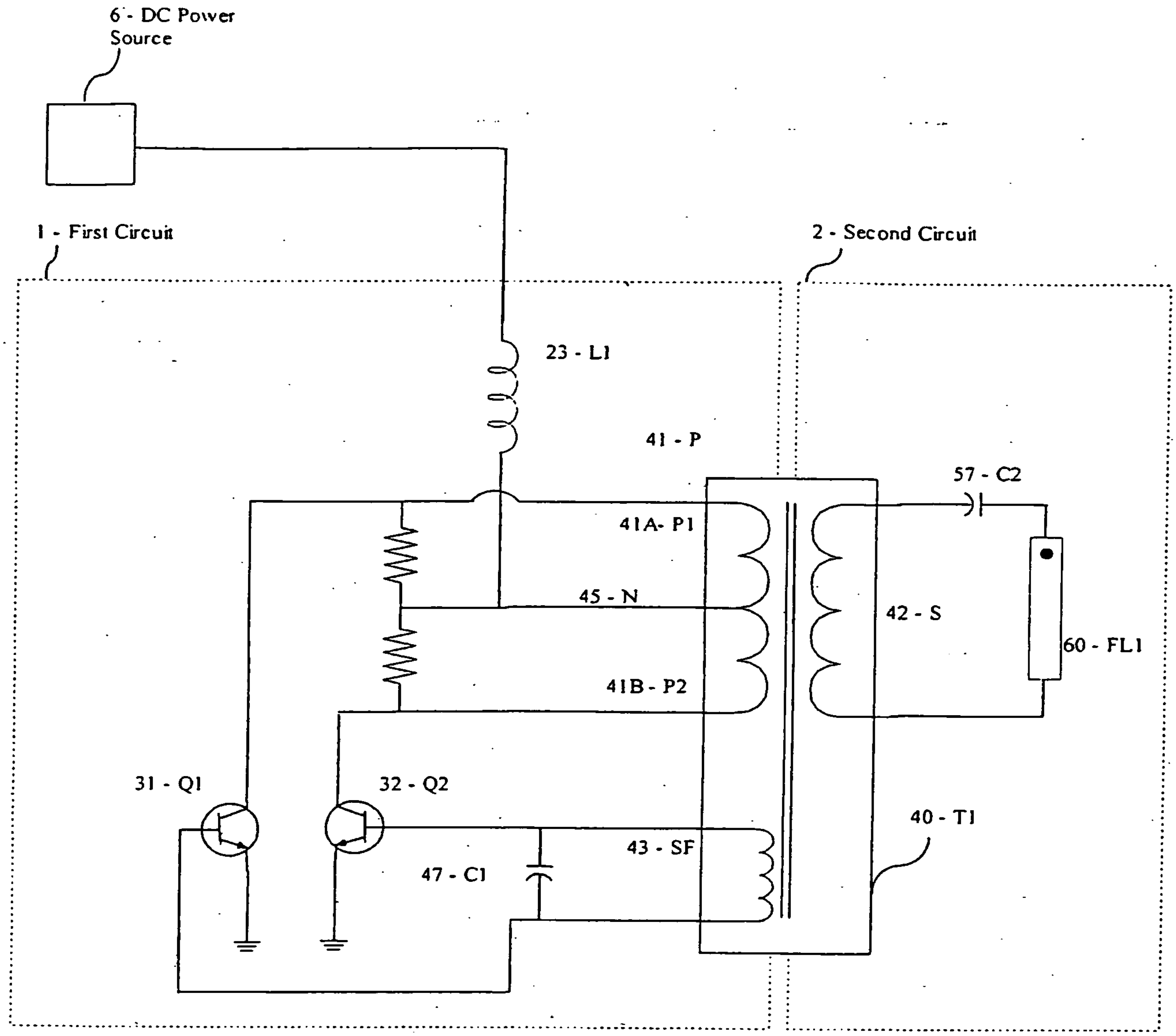

6 - DC Power Source
1 - First Circuit
2 - Second Circuit
23 - L1
41 - P
57 - C2
41A- P1
45 - N
42 - S
60 - FL1
41B - P2
31 - Q1
32 - Q2
40 - T1
43 - SF
47 - C1

FIG. 4

INTERNATIONAL SEARCH REPORT

Inte   onal Application No
PCT/US 02/27962

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B41/282

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WELLS E: "USING THE UC3871 AND UC3872 RESONANT FLUORESCENT LAMP DRIVERS IN FOTING LAMP APPLICATIONS" UNITRODE DESIGN NOTE DN-75, XX, XX, 1997, pages 1-4, XP001051082 figures 1,2 ---	1-22
X	LIN MU-SHEN ET AL: "Primary-side dimming control driver for cold-cathode fluorescent lamps" ELECTRONICS LETTERS, IEE STEVENAGE, GB, vol. 32, no. 15, 18 July 1996 (1996-07-18), pages 1334-1335, XP006005412 ISSN: 0013-5194 figures 1,2 ---	1-22

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 December 2002	09/12/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Maicas, J.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LIN M-S ET AL: "A COLD-CATHODE FLUORESCENT LAMP DRIVER CIRCUIT WITH SYNCHRONOUS PRIMARY-SIDE DIMMING CONTROL" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, IEEE INC. NEW YORK, US, vol. 45, no. 2, 1 April 1998 (1998-04-01), pages 249-255, XP000740818 ISSN: 0278-0046 figures 1-3 ---	1-22
A	US 5 150 013 A (BOBEL ANDRZEJ) 22 September 1992 (1992-09-22) -----	

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/US 02/27962

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5150013 A	22-09-1992	NONE	